Fact Sheet • October 2000

National Spent Nuclear Fuel Program

Criticality Analysis

Mission
Ensure safe handling during storage, transport, and disposal by analyzing spent nuclear fuel properties for criticality potential

Benefits
- Contribute to repository acceptance by satisfying thermal, shielding, and criticality safety constraints
- Ensure fuel stability during interim storage, transportation, and repository disposal

Current Issues
- Some scenarios cannot be examined
- Packaging design and materials could exacerbate criticality potential

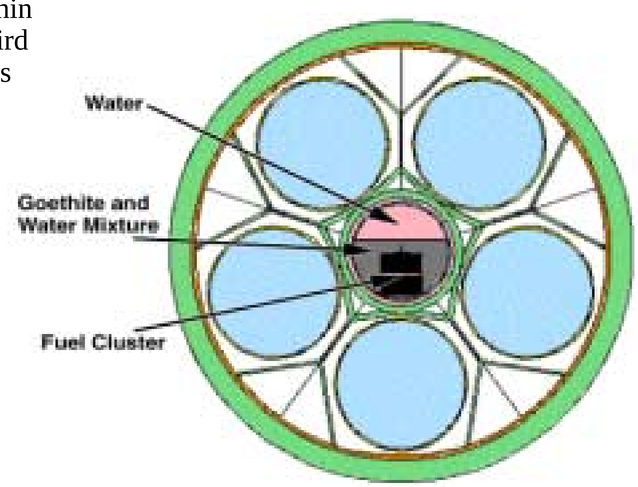
Project Status
- Spent nuclear fuel classified into groups
- Fuel groups being evaluated in Phase I
- Fuel groups being evaluated in Phase II

Purpose
Safely handling and storing the U.S. Department of Energy (DOE)-owned spent nuclear fuel requires careful consideration of potential nuclear criticality. Water intrusion and waste package degradation pose risks to criticality safety that analysts must mitigate when designing packages for fissile material enrichments and mass, and fuel shapes. Handling processes for packaging must address criticality safety in operational facilities (interim storage and repository surface facilities) and during transportation. Control methods to mitigate this risk include moderator exclusion, physical geometry, and the use of neutron absorbers. Performance analyses of the repository post-closure conditions must also address the loss or compromise of one or more of these controls.

Project Description
In the preclosure environment, analysts perform deterministic analyses to demonstrate safe packaging of DOE-owned spent nuclear fuel at the operational facilities using intact fuel and standardized spent nuclear fuel packages. Double contingency plans mitigate the unlikely situation of two independent events occurring simultaneously, thus affecting criticality safety. Operational facilities use monitoring and recovery plans to manage the various risk scenarios in aboveground (preclosure) facilities.

After emplacement of the fuel in the repository (post-closure environment), monitoring and contingency remediation are not possible. Therefore, analysts must calculate criticality safety risk using probability and consequence analyses. They perform three phases of analysis to ensure safe long-term storage in the post-closure environment.

In the first phase, researchers analyze intact fuels within an intact fuel canister for their most reactive configuration. During the second phase, they make predictions on what may happen to degraded fuel, both within the standardized DOE spent nuclear fuel canister and within the waste package. In the third phase, they develop scenarios for fissile material transport out of a breached canister or waste package to analyze fissile accumulations, neutron poison behavior, and moderator presence.



Cross-sectional view of the canister configuration with degraded guide plate and intact spent nuclear fuel.

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Benefits

These analyses will demonstrate that DOE-owned spent nuclear fuel can satisfy the repository thermal, shielding, and criticality safety restraint requirements — a repository fuel acceptance requirement. These criticality studies also contribute to the development of safe fuel packaging guidelines by establishing fissile material limits and neutron poisoning requirements. These guidelines form the basis for safe interim storage, transport, and repository emplacement.

Unique Capabilities

The National Spent Nuclear Fuel Program has access to highly experienced criticality analysis engineers. The program established packaging standards to mitigate the impacts to criticality safety. Also, analysts considered numerous spent nuclear fuel configurations for the probabilistic analyses and identified the risks associated with those scenarios.

Current Issues

Because there are over 250 DOE-owned spent nuclear fuel types and thousands of conditional scenarios, analysts could not efficiently analyze all of the possible combinations. Therefore, they divided the fuel types into groups and analyzed the most reactive fuel in each group under the worst scenario. If that fuel did not affect criticality safety under the particular scenario, analysts considered all of the fuel in the group safe to manage within the worst-case scenario.

Certain packaging materials could introduce unwanted chemical degradation products to the fuel. Therefore, the National Spent Nuclear Fuel Program is sponsoring material studies to identify chemical degradation products and ensure appropriate packaging material selection, and incorporate appropriate neutron poisons into the canisters, at time of loading.

Project Status

Analysts grouped the more than 250 types of DOE-owned spent nuclear and defined a "bounding case" fuel in each group. Analysts are performing and documenting criticality analyses on the most reactive fuels from each of the fuel groups.

The fuel groups were segregated based on a fuel matrix composition. Then, within each group, a candidate fuel type was selected as either most representative or bounding for that group

September 1997
Completed aluminum trial evaluation

November 1997
Officially began project

September 1999
Completed mixed oxide fuel group (MOX) evaluation

January 2000
Completed Training, Research and Isotope General Atomics fuel group (TRIGA) evaluation

February 2000
Completed Shippingport Pressurized Water Reactor (PWR) evaluation

August 2000
Completed Shippingport Light Water Breeder Reactor (LWBR) evaluation

Completed Fermi evaluation

November 2000
Complete N-Reactor evaluation

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